

Interconnection of Wind Generation to the Grid

Colorado Wind and Distributed Energy
Renewables for Rural Prosperity

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Doubletree Hotel

Colorado Springs, CO

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Topics I Will Cover

- How wind generation is Interconnected to the Grid
- Working with Utilities
- Key Technical Issues
- Key Operational Issues
- Power Quality
- System Reliability.



Single 900 kW Wind Turbine
Connected to Distribution Line

65 kW Wind Turbine for Sentral Schools at Fenton, Iowa



Three 65 kW Wind Turbines at Britt, Iowa



600 kW Turbine at School in Forest City, Iowa



Connected by Fuses to Distribution System

Two 950 kW Wind Turbines for the City of Fairmont, Minnesota



**Reclosers Moved
Downstream from
Turbines**

Interconnected with Fuses

MinWind 1 & 2 Wind Farms

Four 950 kW Turbines at LuVerne, Minnesota

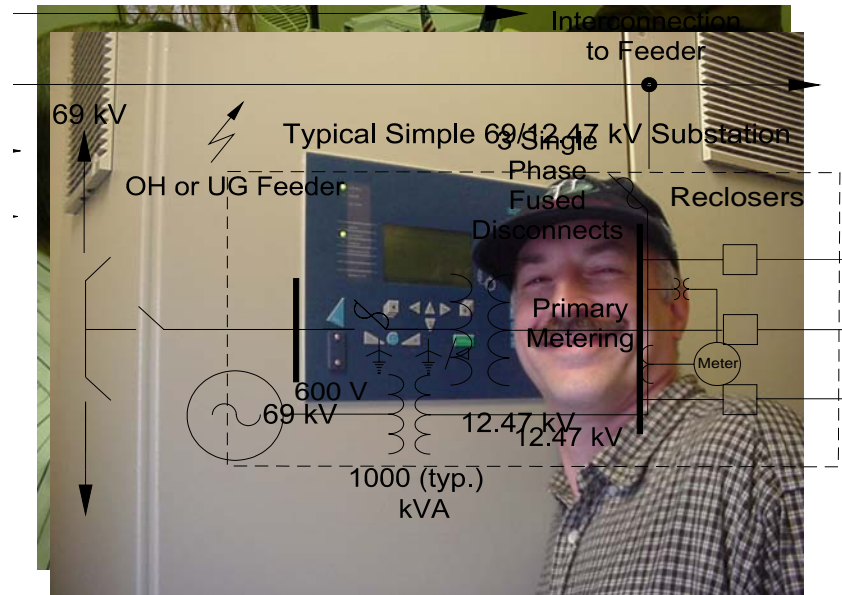


Two Farmer-Owned
Cooperatives, each owns
Two 950 kW wind turbines
Tom Arends, Mark Willers
are the two presidents



Working With Utilities

- Your First Stop.... The Local Utility
 - Most likely buyer because its much simpler
 - Should provide some initial technical guidance on where you might be able to interconnect
 - Should provide technical requirements for interconnection equipment.



The Local Utility Is Your Partner

- Interconnection Agreement specifies:
 - Technical requirements
 - Operating guidelines
 - Emergency procedures
 - Safety considerations
- Power Purchase Agreement (PPA)
 - Purchase price
 - Business practices
 - Stable legal framework
- Long-term relationship.



Key Technical Issues

- Relative size of the wind turbine compared to the capability of the distribution grid
 - Voltage level of distribution grid
 - Distance from substation
 - Size of substation transformer
- Protecting the distribution grid and wind turbine during grid disturbances.



Key Operational Issues

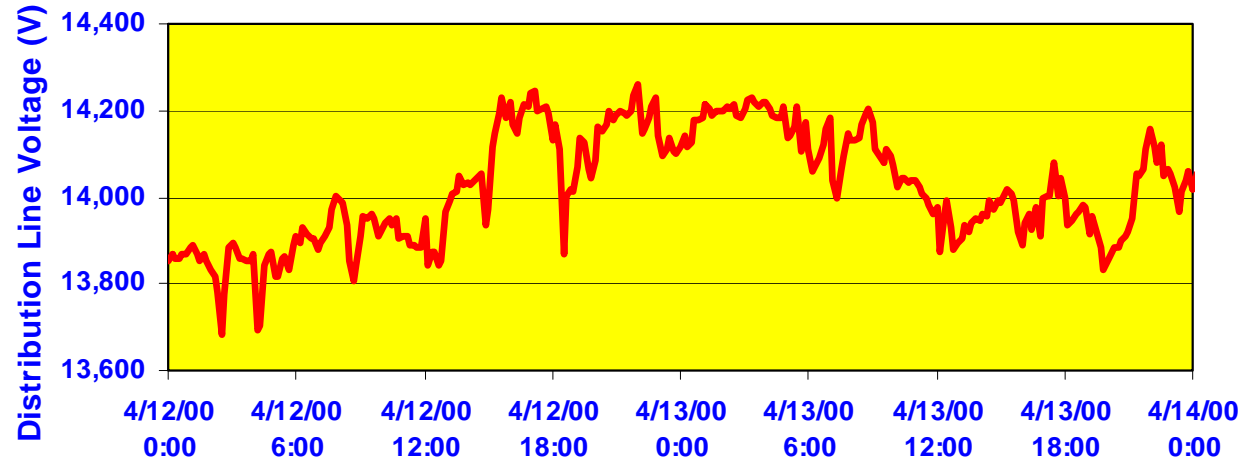
- If wind turbine supplied power to owner's facilities
 - Backfeeding
 - Standby or demand charges
- If wind power is sold wholesale to utility
 - Supervisory control and data acquisition for monitoring
 - Forced shutdowns for transmission grid problems.



Power Quality

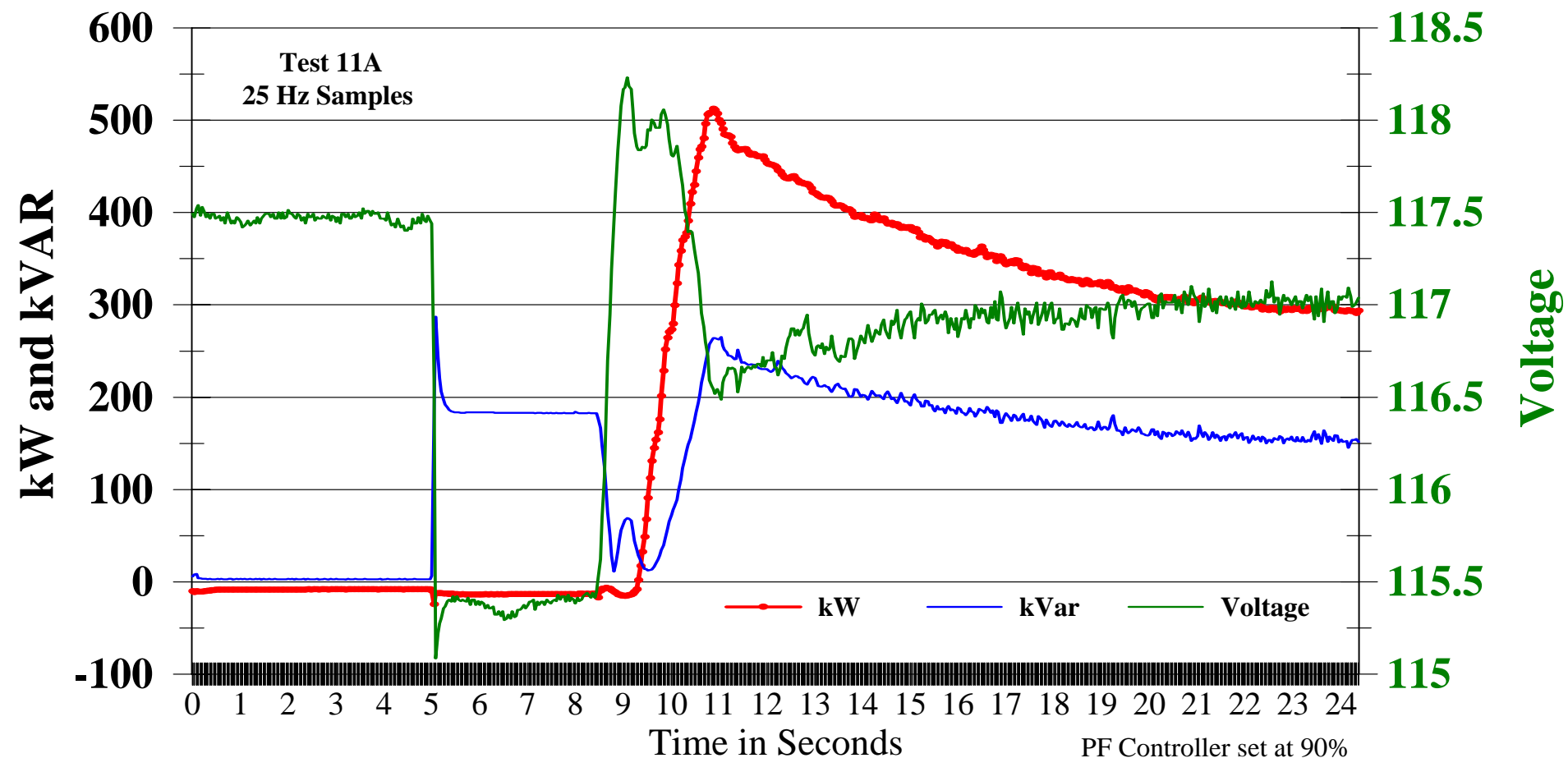
- When a wind turbine starts up, there are current surges or transients
- These current surges cause the voltage on the distribution system to dip slightly
- Voltage dips can be annoying if they are severe or frequent
- Harmonics are not an issue with larger wind turbines.

Distribution
Wind Speed
Line Voltage
Output



Wind Turbine Startup at Algona, Iowa

Real Power, Reactive Power, & Voltage
Zond Z750 Wind Turbine at Algona



Wind Turbine Transient Power

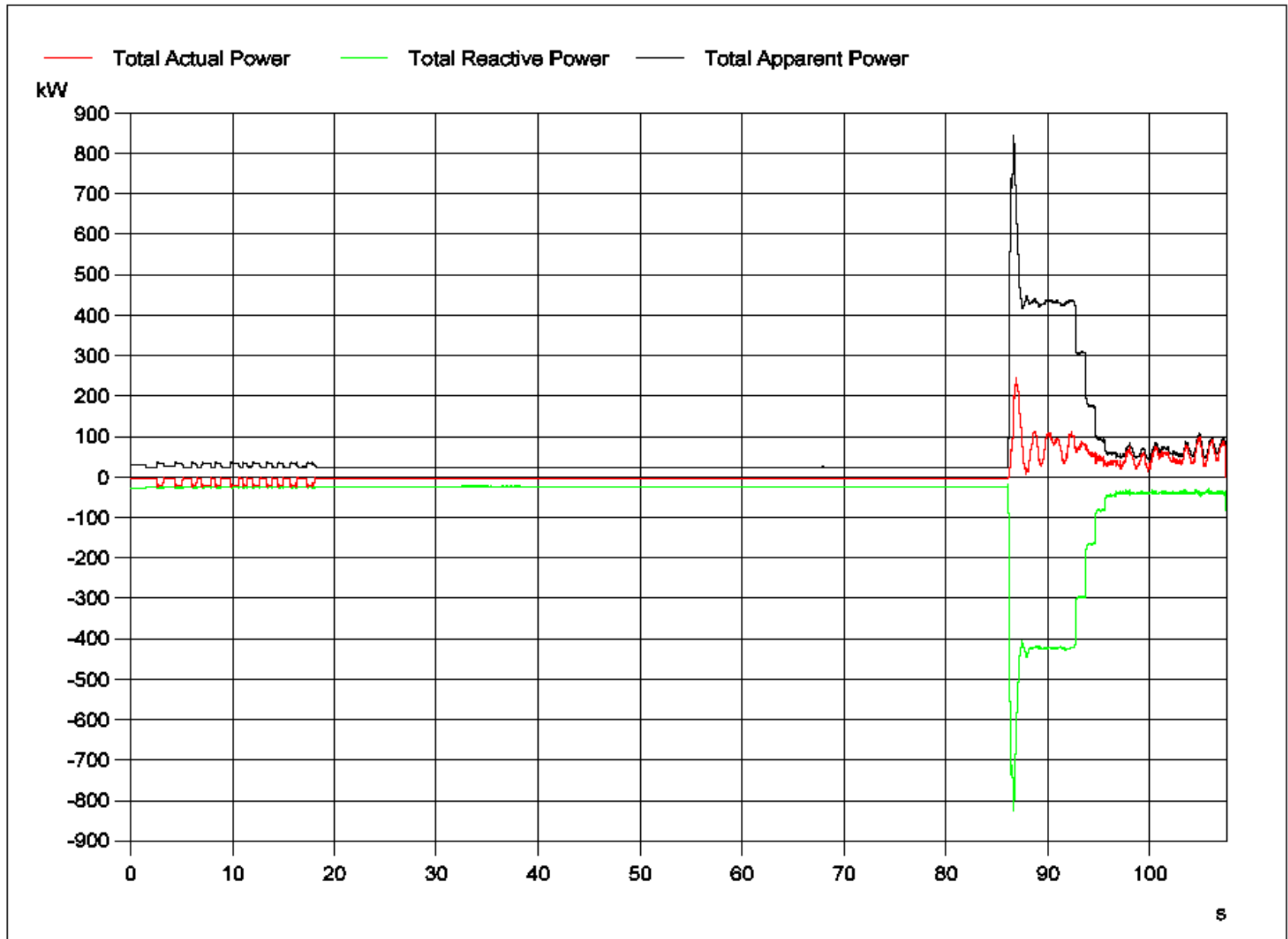


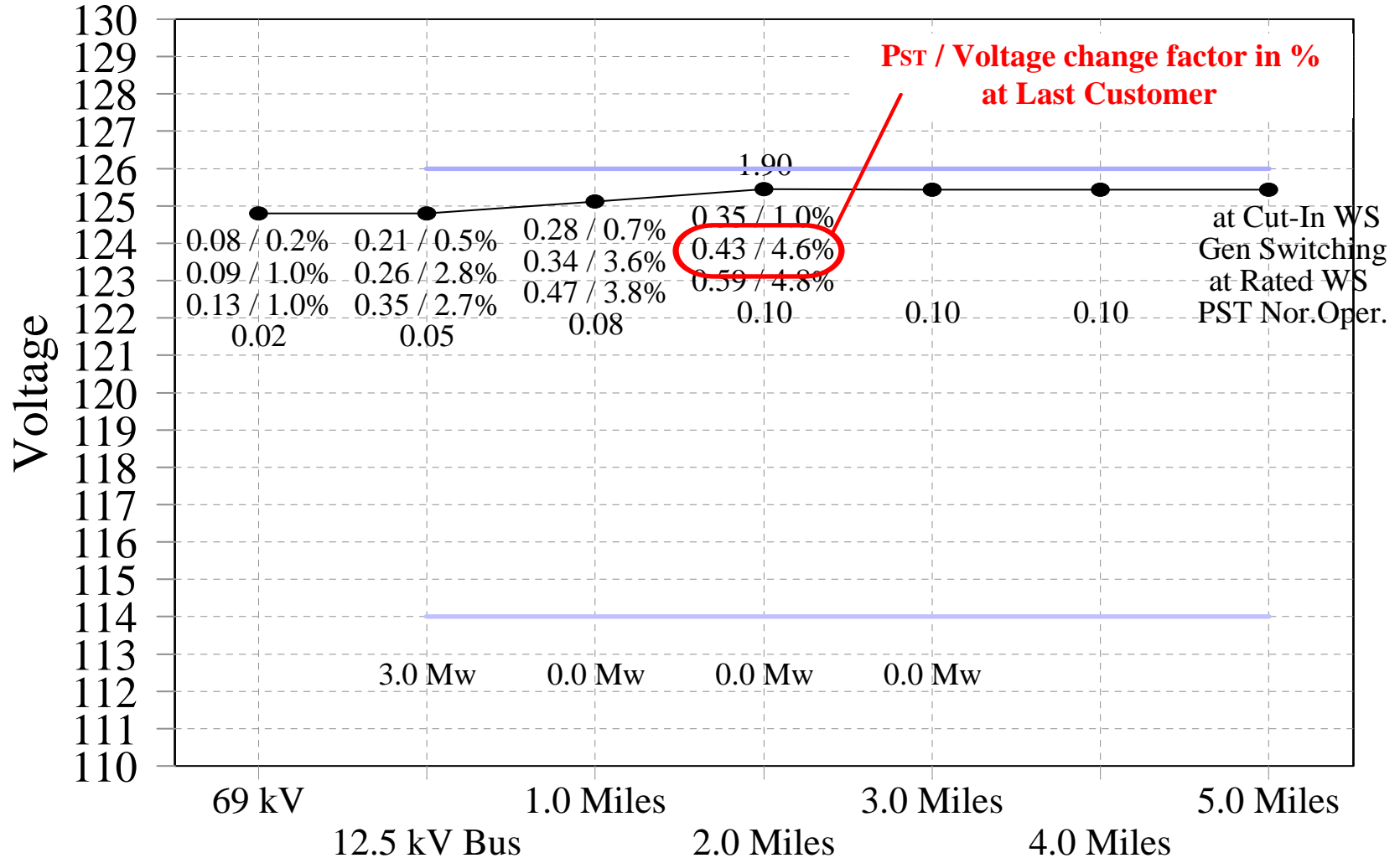
Figure 3.2.6 : Active, reactive and apparent power against time

Example of Flicker Evaluation

Proposed Site With 2 NEG-M 950 WTG

NEG-Micon 950 kW with 4/0 ACSR

Voltage Profile, Voltage Change & Flicker Disturbance Factors



Reliability

- Must ensure that the addition of a wind turbine won't significantly impact feeder reliability
 - Wind turbine should readily trip off on its own for any disturbance, such as grid faults and for high and low voltages
 - Wind turbines also trip for phase unbalance, and over/under frequency
 - Don't want extra unnecessary substation or line recloser operations because of wind turbine.



750 kW Wind Turbines Added in Entire Area

